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The knowledge dynamics of organizational innovation

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Chapter 9

Results and Data Analysis

9.1 Introduction

In *chapter 6* nine hypotheses were formulated derived from the cognitive-semiotic model presented in *chapter 4*. We discuss the data in the following order. First we discuss the data at a descriptive level; that is, we provide a profile of the planners that participated in our study [9.2] and we present the general means and standard deviations to the three knowledge types [9.3]. Secondly, we subject the nine formulated hypotheses to the data obtained for the three knowledge types of sensory knowledge, coded knowledge and theoretical knowledge [9.4]. We then subject the data to more, exploratory, analyses [9.5]. The final section of the present chapter summarizes the main findings [9.6]. The last chapter of this thesis, subsequent to this chapter, elaborates on the implications of the results put forward in the present chapter.

9.2 Planners' profile

In total 43 planners participated in our study. However, not all these planners participated in each of the three measurements; only 18 planners did. As the primary aim of our study is to understand the knowledge dynamics of individual planners in an innovative organizational setting we want to compare *within* subject. Thus, we focus on the 18 planners who participated in all three measurements. The first measurement was before the implementation process of ZKR had started, the second measurement was just after the planners had had their *training* on ZKR and the third measurement was after the planners had had half a year of *experience* with ZKR.

The 18 planners had an average age of 34.6 [SD: 9.0 years] and an average job experience in this position of 9.5 years [SD: 6.7 years]. *Figure 9.1a* shows the numbers of planners of 30 years of age and younger [N = 7] and planners who are older than 30 years of age [N = 11]; *figure 9.1b* shows the amount of novice planners [N = 7] and experienced planners [N = 11]. The planners were relatively highly educated: 13 planners [72 %] were educated at higher level, which corresponds to a bachelor's degree or higher professional vocational education [in the Netherlands: HBO]; the other five planners [28 %] were educated at senior level, which corresponds to senior vocational education [in the Netherlands: MBO; see figure 9.1c]. Regarding their position within the organization of Bartiméus 16 planners were unit members [88 %] and two planners were head of the team for which they worked [12 %]. More than half of the planners worked 32 hours up to full time [10 planners equals 56 % - see also figure 9.1d] and eight planners worked part time [44%]. All but one planner had prior experience with computers. However, this experience was limited to word processing programs such as *Word* and *Word Perfect*.

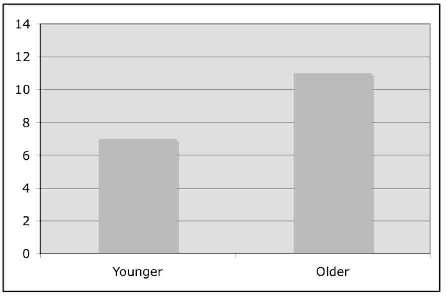


Figure 9.1a: Age of the planners: 30 and younger versus older than 30

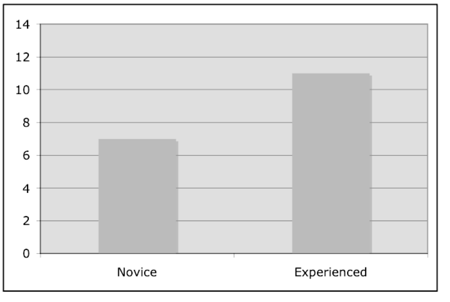


Figure 9.1b: Job experience: novice versus experienced

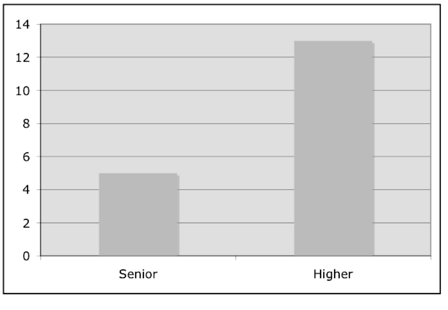


Figure 9.1c: Education: senior versus higher

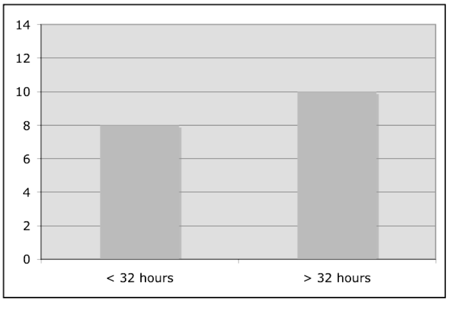


Figure 9.1d: Contractual hours per week: part time versus full time

In short, the planners started working in their current positions at the average age of 25 years. At the time of our study they were around 35 years of age with an average job experience of almost ten years. More than half of this group of relatively highly educated planners – in comparison to other groups of planners studied in the Netherlands Railways [Kiewiet et al. 2005] – worked at least 32 hours [= four days] per week.

9.3 Some preliminary data

In the previous chapter we presented the operationalization of the three concepts of the knowledge types based on content validity and face validity. In order to determine the reliability of the suggested operationalization into the constructs, we conducted a factor analysis after which we calculated Cronbach's alpha for the three knowledge-type constructs. We will discuss the calculation in this section, followed by a descriptive analysis of the data of the first measurement.

9.3.1 Reliability of the constructs

Focusing on reliability our aim was to explore the options of building three stable theoretical constructs from the questions of the questionnaire. Hereto, we took all questions – related to the three different knowledge types – together [43 in total] and subjected this group of questions to a factor analysis. Rather than suggesting three factors that each represented one of the three knowledge types of sensory, coded, and theoretical knowledge, the factor analysis showed a more ambiguous result. The analysis showed that the first three factors only explained 54 percent of the variance [six factors would explain 85 percent]. Also, the three suggested factors contained cross loaded variables.

Therefore, based on this first factor analysis, we selected a group of questions and we conducted three additional factor analyses, one separate factor analysis for each of the three knowledge type constructs. These three separate factor analyses did not suggest three unambiguous knowledge type constructs either.

In determining the three knowledge type constructs our next step was to calculate Cronbach's alpha for the three separate knowledge types. We therefore made two assumptions:

1. We expect a similar configuration for the three subtasks, which would imply that the data over the subtasks are stable
2. We expect a similar configuration for the three measurements, which would imply that the data over the measurements are stable

We used the factor analyses as a starting point to revalue the selection for our three knowledge type constructs. The three groups of questions for which the calculated Cronbach's alpha met our two assumptions [see table 9.1a].

The factor analyses showed

- no clear cut distinction between the three knowledge types
- sensory knowledge was the most clear of all three factors
- reevaluating the highly inter correlated questions, some could not be founded properly enough in theory
- some question that were expected to correlate with one knowledge type in fact showed a higher correlation with another knowledge type
- coded knowledge was the least clear of all three clusters

The calculation of Cronbach's alpha showed

- acceptable correlations that met our two formulated assumptions

So, although the factor analysis was not satisfactory, the calculation of Cronbach's alpha did seem to meet our standards. However, reconsidering the three groups of questions on which Cronbach's alpha had been calculated the outliers [based on the factor analyses] that we excluded, in fact included the questions that we on forehand determined to be the key-questions of the three knowledge types.

Table 9.1a: Cronbach's alpha scores for the three knowledge types groups of questions [key questions not included]

	Sensory		Coded		Theoretical	
	1ST	3RD	1ST	3RD	1ST	3RD
Gathering information	.629	.724	.657	.570	.380	.653
Negotiating	.799	.630	.746	.270	.610	.877

We considered three explanations for these results. Firstly, the data could contain random errors, which we can partly explain by the relatively small N. Secondly, the data could contain systematical errors, which could be explained by possible misinterpretation of the questions by the subjects. Thirdly, the validity of the construct is too low. Although these three explanations are all plausible and a mixture of these three explanations could also be in order we cannot – at this point – be sure, which explanation is leading. This left us with a dilemma, choosing between validity, as a theoretical fundament, and reliability, coherence between the set of questions. Therefore, to be safe we chose to prioritize validity above reliability. Although, a group of questions sounds more attractive as an operationalization than does just one question, we did do just that. So we continued the data analysis and the hypotheses testing operationalizing the three knowledge types with the one key question.

Table 9.1b: Mean scores and SD's for the three knowledge types for the 1ST measurement split on the four personal characteristics

		Sensory		Coded		Theoretical	
		M	SD	M	SD	M	SD
Overall		3,28	0,69	2,67	0,75	4,26	0,46
Age	Younger	3,00	0,70	2,79	0,81	4,14	0,48
	Older	3,45	0,65	2,59	0,74	4,34	0,45
	Difference	+0,45		-0,20		+0,20	
Education	Senior	3,30	0,57	2,20	0,76	4,40	0,42
	Higher	3,27	0,75	2,85	0,69	4,21	0,48
	Difference	+0,03		+0,66		-0,19	
Job experience	Novice	3,07	0,73	2,79	0,81	4,29	0,57
	Experienced	3,41	0,66	2,59	0,74	4,25	0,40
	Difference	+0,34		-0,20		-0,04	
Contractual Hours	Part time	3,50	0,65	2,56	0,86	4,35	0,52
	Full time	3,10	0,70	2,75	0,68	4,20	0,42
	Difference	-0,40		+0,19		-0,15	

9.3.2 Means and standard deviations split on personal characteristics

Before we test our hypotheses we present the mean values and standard deviations for the three knowledge types, split on the four personal characteristics of age, education, job experience and contractual hours [see also table 9.1b]. We added an extra row per personal characteristic, which shows the difference in mean score between the two [sub] groups. The data resemble the first measurement.

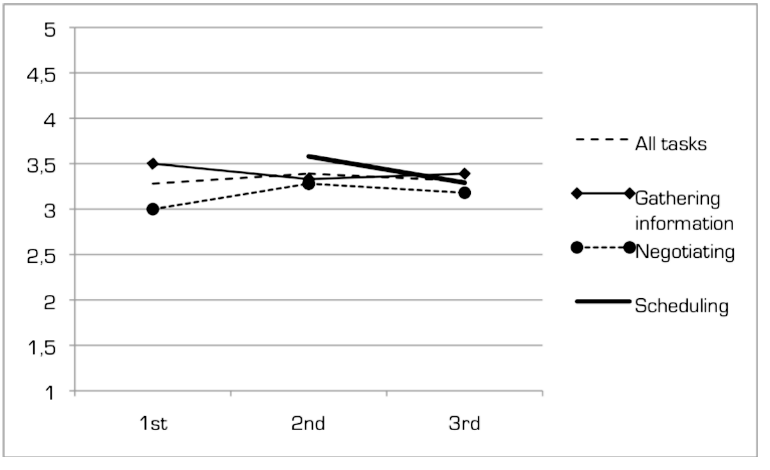
As the table shows the greatest difference is found between the coded knowledge of higher educated planners [HBO] versus senior educated planners [MBO]. Overall, theoretical knowledge shows the smallest difference in score. An interesting contrast forms the group of senior educated planners. Whereas they show the lowest score on coded knowledge compared to all the other grouping of characteristics they show the highest score of theoretical knowledge compared to all the other groups; that translates to a theoretical knowledge that is twice as high as their coded knowledge.

Table 9.1c: Terminology and abbreviations used for in the present chapter

1 / 2	The 1[ST] measurement compared to the 2[ND] measurement: The effect of the *training* with ZKR
2 / 3	The 2[ND] measurement compared to the 3[RD] measurement: The effect of the *experience* with ZKR
1 / 3	The 1[ST] measurement compared to the 3[rd] measurement: The effect of the *implementation* of ZKR
All tasks	All the subtasks together / over all subtasks
GI	Gathering information
N	Negotiating
S	Scheduling
Sens	Sensory knowledge
Cod	Coded knowledge
Theor	Theoretical knowledge

9.4 Hypotheses testing

To test the hypotheses we focused on the effects of both the *training* [the first measurement versus the second measurement] and the *experience* with ZKR [the second measurement versus the third measurement] as well as the effect of the whole *implementation* process [the first measurement versus the third measurement]. *Table 9.1c* shows the three phrases that we use in the following section for these effects. Furthermore, the table shows the abbreviations, for the knowledge types and for the subtasks, that we will use in this chapter to accompany tables and figures. To test the hypotheses we used a paired sampled t-test. The first set of hypotheses is concerned with the main effects of the three knowledge types. Our expectations on sensory knowledge are formulated as follows.



	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
All tasks	3,28	0,69	3,39	0,86	3,31	0,53
Gathering information	3,50	0,86	3,33	0,91	3,39	0,92
Negotiating	3,00	0,69	3,28	1,02	3,18	0,86
Scheduling			3,58	0,98	3,29	0,67

Figure 9.2 and table 9.2a: Mean scores for sensory knowledge for three subtasks over three measurements

9.4.1 Hypotheses 1

Hypothesis 1a

The implementation process of ZKR will lead to a decrease of sensory knowledge for all subtasks

Figure 9.2 and *table 9.2a* below show the mean scores and standard deviations for sensory knowledge over all three measurements for all three subtasks together [first row] and for the three subtasks separately. *Figure 9.2* shows an [non-significant] increase of sensory knowledge during the *implementation* of ZKR [d = 0.04, t = 0.195, df = 17, p = 0.848].

Table 9.2b: Results of the t-test for sensory knowledge

Sensory		η^2	t	df	p
All tasks	Training	0,11	0,456	17	0,654
	Experience	-0,74	-0,345	17	0,734
	Implementation	0,04	0,195	17	0,848
Gathering information	Training	-0,17	-0,644	17	0,528
	Experience	0,06	0,181	17	0,859
	Implementation	-0,11	-0,524	17	0,607
Negotiating	Training	0,28	1,045	17	0,311
	Experience	-0,10	-0,338	17	0,740
	Implementation	0,18	0,656	17	0,520
Scheduling	Experience	-0,26	-1,042	17	0,312

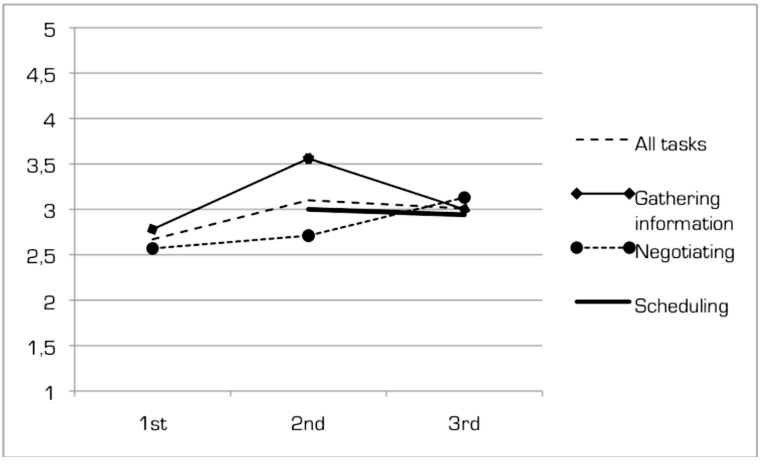
At the level of the subtasks we see an inconsistent pattern. *Gathering information* shows a decrease for sensory knowledge [d = -0.11, t = -0.524, df = 17, p = 0.607] and *negotiating* shows an increase for sensory knowledge [d = 0.18, t = 0.66, df = 17, p = 0.520]. See *table 9.2b* for the other t-test results. In other words, the sensory knowledge of planners does not seem to decrease when they start to make their duty rosters with planning support software. *Hypothesis 1a* could, therefore, not be corroborated. Our expectations on coded knowledge are formulated as follows.

Hypothesis 1b

The implementation process of ZKR will lead to an increase of coded knowledge for all subtasks

Figure 9.3 and *table 9.3a* below show the mean scores and standard deviations for coded knowledge over all three measurements for all three subtasks together [first row of table 9.3a] as well as for the three subtasks separately. The graph shows an increase of coded knowledge for the *implementation* for all three subtasks together. The t-test confirms this effect [d = 0.34, t = 1.891, df = 17, p = 0.076]. The effect of just the *training* on ZKR also shows a significant increase of coded knowledge [d = 0.43, t = 1.811, df = 17, p = 0.088]; the *experience* with ZKR shows a [non-significant] decrease [d = -0.09, t = -0.401, df = 17, p = 0.694]. Thus, during the whole *implementation* of ZKR, coded knowledge increases, in line with *hypothesis 1b*.

At task level the graph shows – over the whole *implementation* stage – an increase for the subtasks *gathering information* and negotiating; *negotiating* shows a significant increase [d = 0.56, t = 1.968, df = 17, p = 0.066*]. Interestingly, gathering information also shows a significant increase on coded knowledge, for the *training* on ZKR [d = 0.78, t = 2.961, df = 17, p = 0.066*]. However, the coded knowledge of gathering information also shows a *d*ecreasing effect for the *experience* with ZKR [d = -0.56, t = -1.966, df = 17, p = 0.009***]. These two contrasting, significant, effects balance each other in that the increase of coded knowledge disappears over the whole *implementation* of ZKR [d = 0.22, t = 1.074, df = 17, p = 0.298]. The coded knowledge for the subtask of scheduling showed a [non-significant] decrease of coded knowledge for *experience* with ZKR [d = -0.06, t = -0.215, df = 17, p = 0.832]. See *table 9.3b* below for the other t-test results.



Coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
All tasks	2,67	0,75	3,10	0,93	3,01	0,77
Gathering information	2,78	1,00	3,56	0,86	3,00	0,97
Negotiating	2,57	0,74	2,71	1,13	3,13	1,08
Scheduling			3,00	1,14	2,94	0,87

Figure 9.3 and table 9.3a: Mean scores and SD's for coded knowledge for three subtasks for three measurements

In other words, the *implementation* of ZKR has the effect of an increase in the coded knowledge of the planners. This effect manifests itself most prominently in the subtask of negotiating; this task shows a linear increase of coded knowledge and a significant increase over the whole *implementation* process. Then, for gathering information, the planners seem to be able to better verbalize their knowledge after the training on ZKR. But this amelioration on verbalization almost disappears after the planners have had half a year of experience with ZKR. Only a shred of an increasing trend seems to be left. The coded knowledge on scheduling does not seem to be affected by the experience with ZKR.

Our expectations on theoretical knowledge are formulated as follows.

Table 9.3b: Results of the t-test for coded knowledge

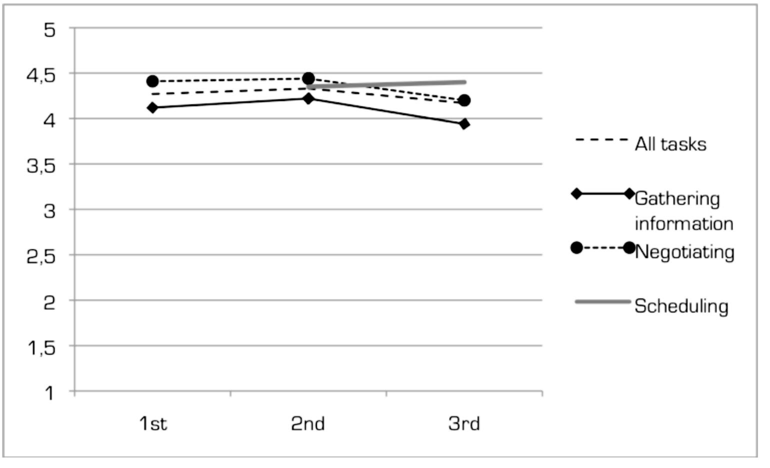
Coded		η^2	t	df	p
All tasks	Training	0,43	1,811	17	0,088*
	Experience	-0,09	-0,401	17	0,694
	Implementation	0,34	1,891	17	0,076*
Gathering information	Training	0,78	2,961	17	0,009***
	Experience	-0,56	-1,966	17	0,066*
	Implementation	0,22	1,074	17	0,298
Negotiating	Training	0,13	0,471	17	0,644
	Experience	0,43	1,312	17	0,207
	Implementation	0,56	1,968	17	0,066*
Scheduling	Experience	-0,06	-0,215	17	0,832

Hypothesis 1c

The implementation process of ZKR will lead to an increase of theoretical knowledge for all subtasks

Figure 9.4 and *table 9.4a* show the mean scores and standard deviations for theoretical knowledge over all three measurements for all three subtasks together [first row] and for the three subtasks separately. The graph appears to show that the theoretical knowledge of the planners decreases during the *implementation* of ZKR. The mean scores for the three subtasks together show a very small increase of theoretical knowledge for the *training* on ZKR [d = 0.0, t = 0.511, df = 17, p = 0.616] and a small decrease for the *experience* with ZKR [d = -0.17, t = -1.319, df = 17, p = 0.205]. All together, the theoretical knowledge of the planners [non-significantly] decreases during the *implementation* of ZKR [d = -0.10, t = -0.703, df = 17, p = 0.491].

At the level of the subtasks we see a [non-significant] decrease for both gathering information [d = -0.18, t = -0.634, df = 16, p = 0.534] and negotiating [d = -0.21, t = -0.929, df = 16, p= 0.366] on theoretical knowledge during the implementation of ZKR. Scheduling shows an increase for theoretical knowledge for the *experience* with ZKR [d = 0.05, t = 0.369, df = 16, p= 0.716]. In other words, the theoretical knowledge of planners did not change during the implementation of ZKR. We did, however, see a consistent decrease of theoretical knowledge [see table 9.4b for the other t-test results].



Theoretical	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
All tasks	4,27	0,46	4,33	0,55	4,17	0,55
Gathering information	4,12	0,58	4,22	1,00	3,94	1,16
Negotiating	4,41	0,60	4,44	0,62	4,20	0,98
Scheduling			4,35	0,68	4,40	0,57

Figure 9.4 and table and figure 9.4a: Mean scores for theoretical knowledge for three subtasks over three measurements

Summarizing *hypothesis 1*, overall, during the implementation of ZKR the coded knowledge of the planners increases. The separate subtask of negotiating shows this effect as well. Gathering information shows an increase of coded knowledge, however only for the training, while the experience with ZKR for gathering information even shows a *de*crease of coded knowledge. The implementation neither shows a significant increase nor a significant decrease for both theoretical knowledge and sensory knowledge. Theoretical knowledge does show a decreasing trend overall, for gathering information and for negotiating on experience as well as over the whole implementation process. Sensory knowledge shows the least consistent change patterns of all three knowledge types.

Table 9.4b: Results of the t-test for theoretical knowledge

Theoretical		η^2	t	df	p
All tasks	Training	0,07	0,511	17	0,616
	Experience	-0,17	-1,319	17	0,205
	Implementation	-0,10	-0,703	17	0,491
Gathering information	Training	0,10	0,433	17	0,670
	Experience	-0,28	-0,813	17	0,428
	Implementation	-0,18	-0,634	17	0,534
Negotiating	Training	0,03	0,189	17	0,852
	Experience	-0,24	-0,887	17	0,388
	Implementation	-0,21	-0,929	17	0,366
Scheduling	Experience	0,05	0,369	17	0,716

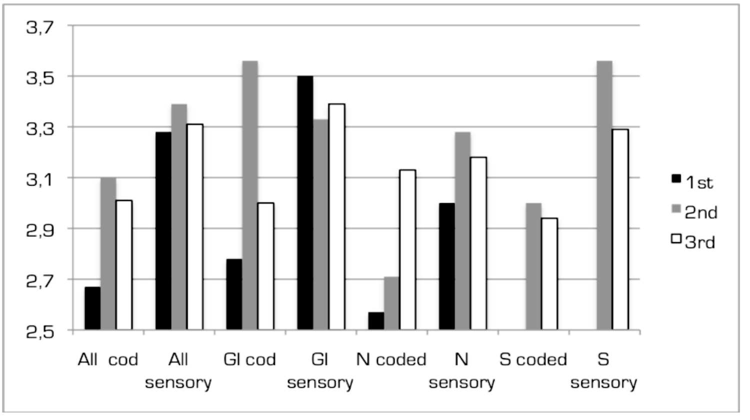
Hypothesis 2 combines *hypothesis 1a* and hypothesis 1b; that is, we hypothesized an increase for coded knowledge in combination with a decrease for sensory knowledge. We formulate *hypothesis 2* as follows.

9.4.2 Hypothesis 2

Hypothesis 2

The implementation process of ZKR will lead to a conversion of knowledge from sensory knowledge into coded knowledge

Hypothesis 1b showed that the *implementation* of ZKR resulted in an increase for the coded knowledge of the planners; however, *hypothesis 1a* showed that this was not combined with a decreasing effect for their sensory knowledge.



Conversion	1ST	2ND	3RD
All tasks coded	2,67	3,10	3,01
All tasks sensory	3,28	3,39	3,31
Gl coded	2,78	3,56	3,00
Gl sensory	3,50	3,33	3,39
N coded	2,57	2,71	3,13
N sensory	3,00	3,28	3,18
S coded		3,00	2,94
S sensory		3,56	3,29

Figure 9.5 and table 9.5a: The mean values for the three knowledge types for all subtasks, as well as for all three measurements
[To optimize the visibility of the direction of the trends we changed the range of the scale of figure 9.5 from 1 - 5 to 2,5 - 3,7]

We now want to investigate whether increases of coded knowledge are accompanied by decreases of sensory knowledge, apart from the size of the change. In other words, we focus on the combination of directions of the knowledge change rather than on the size of the knowledge change [in p-values]. *Figure 9.5* and *table 9.5a* show the mean scores for all subtasks together and the three subtasks separately. When we take a closer look at the coded knowledge and the sensory knowledge for all subtasks [the two column groups on the left of figure 9.5] we see for both sensory knowledge and coded knowledge an increase for the *training* [black and grey columns] Then for the *experience* with ZKR [grey and white columns] we see a decrease for both sensory knowledge and coded knowledge. Thus, over all subtasks do neither the *training* on ZKR nor the *experience* with ZKR show the expected knowledge conversion pattern as formulated in *hypothesis 2*, an increase of coded knowledge in combination with a decrease of sensory knowledge.

To test *hypothesis 2* there are ten possible combination patterns showed in *figure 9.5*. *Table 9.5b* specifies these ten combinations.

Table 9.5b: Overview of the possible combination patterns to test the conversion of sensory knowledge into coded knowledge

Conversion	Training effect [black-gray]	Experience effect [gray-white]	Implementation effect [black-white]
All tasks together	X	X	X
Gathering information	X	X	X
Negotiating	X	X	X
Scheduling		X	

Each of these ten combinations can be placed in one of four combination-categories [see table 9.5c], that is, a 2 [increasing coded knowledge or decreasing coded knowledge] x 2 [increasing sensory knowledge or decreasing sensory knowledge] table:

- An increase of coded knowledge combined with an increase of sensory knowledge
- An increase of coded knowledge combined with a decrease of sensory knowledge

- A decrease of coded knowledge combined with an increase of sensory knowledge
- A decrease of coded knowledge combined with a decrease of sensory knowledge

For the purpose of testing *hypothesis 2* we are interested in the second group. *Table 9.5c* [below] places all ten combinations in one the four quadrants; each quadrant is divided into twelve cells, three columns for effect [training, experience, and implementation] x four rows for task [all tasks together, gathering information, negotiating, scheduling]. *Table 9.5c* also shows the effect size [in p-values] for the differences in knowledge. For example, *quadrant 3* shows one combination; decreasing coded knowledge with a *p-value* of .07 together with increasing sensory knowledge with a *p-value* of .86. This combination applies to the effect of *experience* with ZKR for the subtask of gathering information. *Quadrant II* supports *hypothesis 2* and *quadrant III* contradicts *hypothesis 2*. Both *quadrant I* and *quadrant IV* combine a knowledge type change in line with hypothesis together with a knowledge type change contradictory to *hypothesis 2.*

Table 9.5c shows three combinations in line with *hypothesis 2* [quadrant II], one combination which contradicts *hypothesis 2* [quadrant III], and 6 combinations that have both a change direction in line with *hypothesis 2* as well as a change direction that contradicts *hypothesis 2*. Thus, *table 9.5c* shows that three of the ten possible combinations are in line with *hypothesis 2.* These three combinations concern gathering information [two times] and negotiating [once] and they refer to the *training*, the *experience* as well as the overall *implementation*. We conclude that our expectation on the conversion of coded knowledge into sensory knowledge is not supported.

The *hypotheses 1* and *2* concerned the main effects of the three knowledge types. In sum, the coded knowledge of the planners increased when they started to make their duty rosters with ZKR, the *training* that the planners had on ZKR [not the experience] mainly caused this effect. In fact, the coded knowledge during the *experience* that these planners had with ZKR reduced the overall effect, over the whole *implementation* period. Neither sensory knowledge nor theoretical knowledge either increased or decreased significantly, although we did see that the theoretical knowledge patterned a decrease. Finally, we did not find support for the assumption that planners who started to work with ZKR converted their sensory knowledge into coded knowledge.

Hypotheses 3 to *6* formulate expectations on the moderating effect of four planner-related-characteristics on the relationship between the knowledge types and the implementation process of ZKR. One of these four characteristics is job experience. So, for example, we expect the knowledge change pattern of novice planners to differ from the knowledge change pattern of experienced planners.

Table 9.5c: P-values the effects of training [1/2], experience [2/3] and implementation [1/3] for sensory knowledge and coded knowledge
Δ = increase, ∇ = decrease

		Δ sensory			∇ sensory		
		1 / 2	1 / 3	2 / 3	1 / 2	1 / 3	2 / 3
Δ coded	All	C: .09* S: .66		C: .08* S: .85			
	GI				C: .01* S: .53		C: .30 S: .61
	N	C: .64 S: .31		C: .07 S: .52		C: .21 S: .74	
	S			I	II		
∇ coded	All		C: .07* S: .86	III	IV	C: .69 S: .73	
	GI						
	N						
	S					C: .83 S: .31	

The four characteristics on which we formulated expectations of their moderating effect are respectively education [senior vocational versus higher vocational education: *hypothesis 3*], job experience [novice versus experienced: *hypothesis 4*], age [younger versus older: *hypothesis 5*] and contractual hours per week [part time versus full time: *hypothesis 6*]. To illustrate the testing procedure that we followed we will first formulate *hypothesis 3a* and use this hypothesis as an example.

9.4.3 Hypotheses 3

Hypothesis 3a

During the implementation process of ZKR planners with higher professional vocational education will show a stronger increase of their sensory knowledge in comparison to planners with senior vocational education.

Hypothesis 3a formulates the expectation that the education of planners influences their coded knowledge when they start to work with ZKR. More specifically, we expect that starting to work with ZKR will cause a greater increase in the sensory knowledge of higher educated planners than in the sensory knowledge of senior educated planners. *Table 9.6a* shows fictitious raw data – as illustration to explain the computational procedure – for the sensory knowledge of four planners. The rows present the data per planner, the first column [starting from the left] showing the scores for sensory knowledge for the first measurement, the second column showing the scores for the second measurement and the third column showing the scores for the third

	1st	2nd	3rd	Education
Planner 1	3	4	5	Higher
Planner 2	1	2	3	Higher
Planner 3	4	5	4	Senior
Planner 4	4	5	5	Senior

Hypothesis 1a

Table 9.6a: Fictitious raw data for the sensory knowledge of four planners to illustrate the data used for the different hypotheses

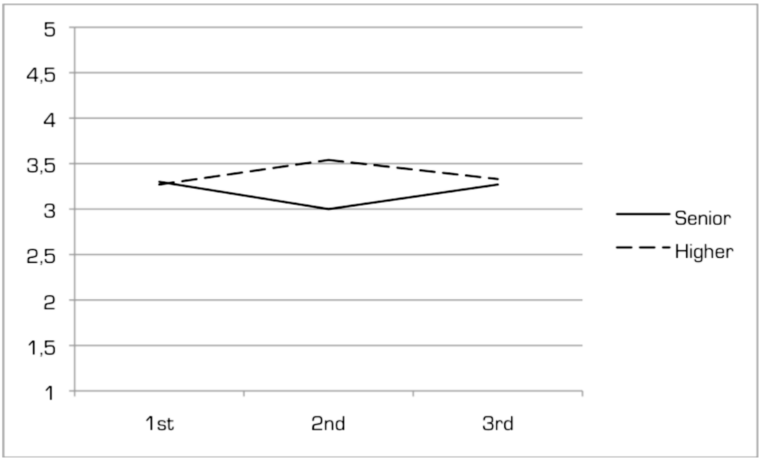
Hypothesis 3a

1/2	2/3	1/3
1	1	2
1	1	2
1	-1	0
1	0	1

Table 9.6b: New variables: The difference scores derived from table 9.6a

measurement for sensory knowledge. *Table 9.6b* displays the difference scores differentiated from *table 9.6a*; the 1/2-column shows the score differences between the first and the second measurement – the effect of the *training*, the 2/3-column shows the score differences between the second and third measurement – the effect of the *experience* with ZKR – and the 1/3-column shows the score differences between the first and third measurement – the effect of the whole *implementation*.

Hypothesis 1 was tested on the raw data, as presented in *table 9.6a*. For example, to test the effect of the training on the sensory knowledge [hypothesis 1a] we compared the first *column* to the second *column* using a dependent t-test. *Hypotheses 3* to *6* will test differentiated data, as in *table 9.6b*. For example, to test the difference in effect of the *training* on sensory knowledge between higher educated planners and senior educated planners [hypothesis 3a] we compared the first two *rows* of column 1/2 to the third and fourth *row* of column 1/2.



Education sensory	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
Senior	3,30	0,57	3,00	1,05	3,27	0,64
Higher	3,27	0,75	3,54	0,76	3,33	0,51

Figure 9.6a and table 9.6d: Mean values and SD's for sensory knowledge over three measurements split on education

So in fact, to test the difference in sensory knowledge between the higher and senior educated planners we calculated ten new difference-score-variables [see also table 9.4b]. Note that *table 9.6a* only shows the three new variables for the overall sensory knowledge; one level deeper we also have the sensory knowledge of the three subtasks – seven additionally. The testing of *hypothesis 1* differs from *hypotheses 3* to *6* on the following points

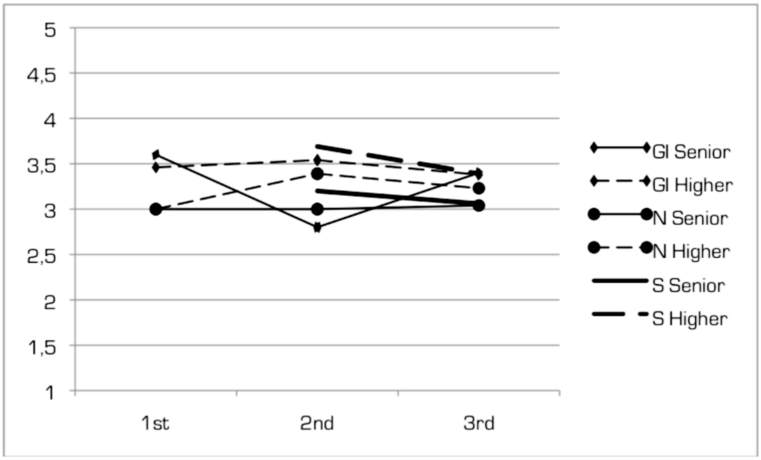
1. Hypothesis 1 is based on *raw* data, hypotheses 3 to 6 are based on *differentiated* data
2. Hypothesis 1 is t-tested as dependent and hypotheses 3 to 6 are t-tested as *in*dependent
3. Hypothesis 1 compares *within* subjects and hypotheses 3 to 6 compare *between* subjects

Figure 9.6a and *table 9.6d* show the mean scores and standard deviations for sensory knowledge split on education. The education of the planners has no effect on the overall *implementation* of ZKR [$\eta^2 = 0.003$, $t = -0.223$, $df = 16$, $p = 0.826$]. The graph does show that the education of the planners affects their sensory knowledge after the *training* on ZKR; however, this effect does not hold in the t-test [$\eta^2 = 0.064$, $t = -1.050$, $df = 16$, $p = 0.310$]. When the planners have had *experience* with ZKR the knowledge change caused by the training on ZKR disappears [$\eta^2 = 0.057$, $t = 0.983$, $df = 16$, $p = 0.340$]. *Table 9.6e* shows an overview of all the t-test scores. Thus,

- Overall education does not affect the innovation – sensory knowledge relation
- The combination of change directions caused by the *training* confirms that higher vocational planners show a stronger increase of sensory knowledge than do senior vocational planners

When we go one level deeper [see figure 9.6b and table 9.6e] the sensory knowledge pattern of senior vocational planners for gathering information is most striking: a decrease of sensory knowledge caused by the *training* and then an increase after *experience* with ZKR. In contrast, the sensory knowledge of the higher vocational planners hardly seems to have been affected by the implementation of ZKR. Although the graph shows this effect for education, the t-test only shows a trend for training [the *training*: $\eta^2 = 0.135$, $t = -1.583$, $df = 16$, $p = 0.133$, and the *experience* [$\eta^2 = 0.071$, $t = 1.105$, $df = 16$, $p = 0.286$].

The sensory knowledge change patterns for negotiating differ from gathering information in that the higher vocational planners show an effect for the *training* and the senior vocational planners hardly seem to be affected by the *implementation* of ZKR. This does not influence education however [training: $\eta^2 = 0.025$, $t = -0.637$, $df = 16$, $p = 0.533$ – see *table 9.6f* for the other t-test results].



Education sensory	1^ST		2^ND		3^RD	
	M	SD	M	SD	M	SD
GI Senior	3,60	0,89	2,80	0,84	3,40	0,89
GI Higher	3,46	0,88	3,54	0,88	3,38	0,96
N Senior	3,00	1,00	3,00	1,41	3,04	0,08
N Higher	3,00	0,58	3,39	0,87	3,23	1,01
S Senior			3,20	1,48	3,06	0,72
S Higher			3,69	0,75	3,39	0,65

Figure 9.6b and table 9.6e: Mean values for sensory knowledge split on education

The sensory knowledge change pattern for scheduling does not seem to be affected by the education of the planners; although the higher vocational planners score higher on sensory knowledge their change pattern does not differ from the change pattern of senior vocational planners [$\eta^2 = 0.005$, $t = 0.219$, $df = 16$, $p = 0.776$]. *Table 9.6f* gives an overview of all the t-test scores.

Thus, testing *hypothesis 3a* for the effect of the education of the planners on the relation between their sensory knowledge and the implementation of ZKR we conclude

- Education does not have a significant effect on the sensory knowledge of planners

- Although not significant, all *implementation* knowledge change patterns and *training* knowledge change patterns are in line with hypothesis 3a – the whole *implementation* process of ZKR and the *training* on ZKR separately cause a stronger increase of sensory knowledge for higher vocational planners than for senior vocational planners
- All knowledge change patterns on *experience* with ZKR contradict hypothesis 3a

Table 9.6f: T-test scores for sensory knowledge split on education for all three subtasks and all differences in measurements

		η^2	t	df	p
All tasks	Training	0,064	-1,050	16	0,310
	Experience	0,057	0,983	16	0,340
	Implementation	0,003	-0,223	16	0,826
Gathering information	Training	0,135	-1,583	16	0,133
	Experience	0,071	1,105	16	0,286
	Implementation	0,004	-0,253	16	0,804
Negotiating	Training	0,025	-0,637	16	0,533
	Experience	0,005	0,275	16	0,787
	Implementation	0,006	-0,317	16	0,755
Scheduling	Experience	0,005	0,219	16	0,776

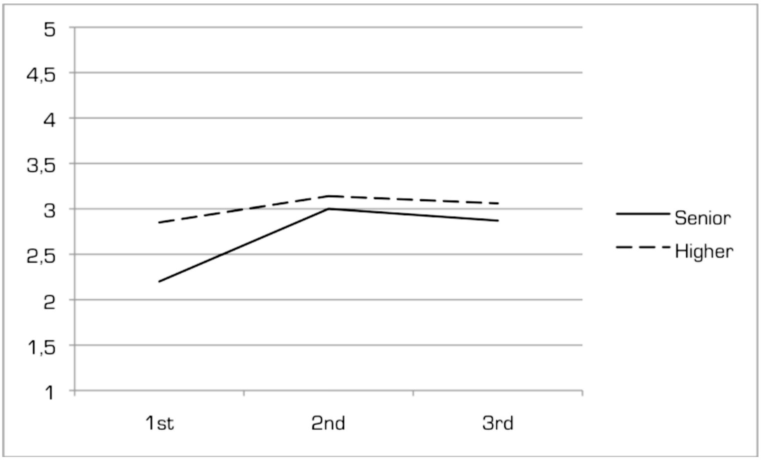
In addition to the effect of education that we expected on sensory knowledge we also expected an effect of education on coded knowledge. In contrast to our expectations for sensory knowledge, we formulated the following hypothesis for the effect of education on coded knowledge.

Hypothesis 3b

During the implementation process of ZKR senior vocationally educated planners will show a stronger increase of coded knowledge in comparison to higher vocationally educated planners.

Figure 9.7a and *table 9.7a* below show the mean scores and standard deviations for coded knowledge split on education.

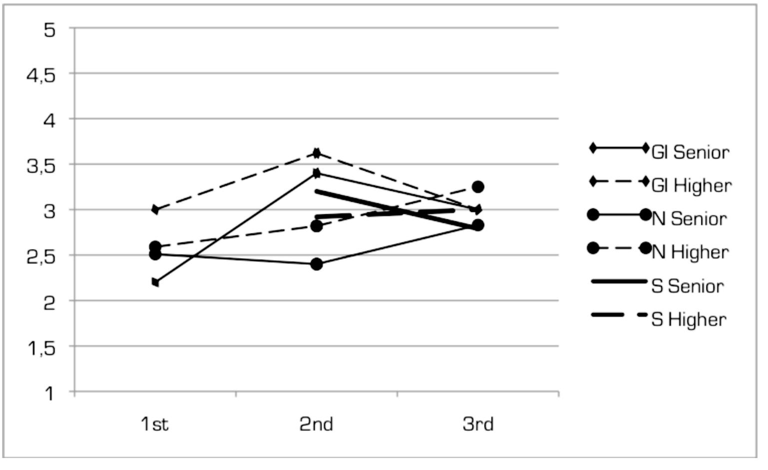
The graph suggests a greater effect on coded knowledge for the senior vocational planners compared to the higher vocational planners, but this effect does not show in the t-test [*training*: $\eta^2 = 0.052$, $t = 0.938$, $df = 16$, $p = 0.362$; *implementation*: $\eta^2 = 0.073$, $t = 1.121$, $df = 16$, $p = 0.279$]. Secondly, the *training* appears to have a greater effect than the *experience* with ZKR, for both the higher educated and the senior educated planners [see table 9.7c for an overview of all the t-test results]. Thus, we sum up



Education coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
Senior	2,20	0,76	3,00	0,97	2,87	0,69
Higher	2,85	0,69	3,14	0,95	3,06	0,82

Figure 9.7a and table 9.7a: Mean values and SD's for coded knowledge split on education

- Overall education does not affect the innovation – coded knowledge relation
- The *training* on ZKR has a greater effect on coded knowledge than does the *experience* with ZKR
- The knowledge change direction of the *implementation* and the *training* are in line with hypothesis 3b – the implementation of ZKR causes a stronger increase of coded knowledge for the senior vocational educated planners than it does for the higher vocational educated planners



Education coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
GI Senior	2,20	1,10	3,40	0,89	3,00	1,22
GI Higher	3,00	0,91	3,62	0,87	3,00	0,91
N Senior	2,51	1,12	2,40	0,89	2,83	0,85
N Higher	2,59	0,61	2,82	1,21	3,25	1,16
S Senior			3,20	1,30	2,79	0,83
S Higher			2,92	1,12	3,00	0,91

Figure 9.7b and table 9.7b: Mean values for coded knowledge split on education

When we go one level deeper [see figure 9.7b and table 9.7b], we see that the effect for *training* over all tasks [figure 9.7a] is probably mainly caused by the subtask of gathering information, which shows similar patterns. The *training* on ZKR does not seem to be affected by the education of the planners [$\eta^2 = 0.058$, $t = 0.997$, $df = 16$, $p = 0.334$], but the whole *implementation* process is affected by the education of the planners [$\eta^2 = 0.176$, $t = 1.850$, $df = 16$, $p = 0.083$]; the increase of the coded knowledge of the senior vocational educated planners is bigger than that of the higher vocational educated planners [in line with hypothesis 3b].

In contrast, for negotiating the higher vocationally educated planners seem to show a stronger increase of coded knowledge than do the senior vocational planners during the *implementation* of ZKR [$\eta^2 = 0.017$, $t = -0.531$, $df = 16$, $p = 0.603$]. Scheduling also shows a contradictory pattern to *hypothesis 3b*, but not strong enough to show in the t-test [$\eta^2 = 0.038$, $t = -0.793$, $df = 16$, $p = 0.440$].

Thus, for *hypothesis 3b*, the effect of the education of the planners on the relation between their coded knowledge and the implementation of ZKR, we conclude

- The knowledge change direction set by the education on coded knowledge over all tasks, for the whole *implementation* process as well as the *training* on ZKR, is conform our expectation – senior educated planners have stronger increasing coded knowledge than do higher educated planners
- Education does not differentiate the planners' coded knowledge of gathering information
- The change directions of negotiating and scheduling, although not significant, are contradictory to hypothesis 3b; they show a greater increase of coded knowledge for the higher educated planners compared to the senior educated planners
- Gathering information shows a knowledge change direction opposite to those of negotiating and scheduling

Interestingly, over all three subtasks we see a decrease of sensory knowledge in combination with an increase of coded knowledge for the senior vocationally educated planners for the effect of the *training*. This pattern manifests itself also for the subtask of gathering information.

Table 9.7c: T-test scores for coded knowledge split on education for all three subtasks and all difference in measurements

Education coded		η^2	t	df	p
All tasks	Training	0.052	0.938	16	0,362
	Experience	0,001	-0,103	16	0,919
	Implementation	0,073	1,121	16	0,279
Gathering information	Training	0,058	0,997	16	0,334
	Experience	0,007	0,332	16	0,744
	Implementation	0,176	1,850	16	0,083*
Negotiating	Training	0,017	-0,529	16	0,604
	Experience	0,000	-0,001	16	0,999
	Implementation	0,017	-0,531	16	0,603
Scheduling	Experience	0,038	-0,793	16	0,440

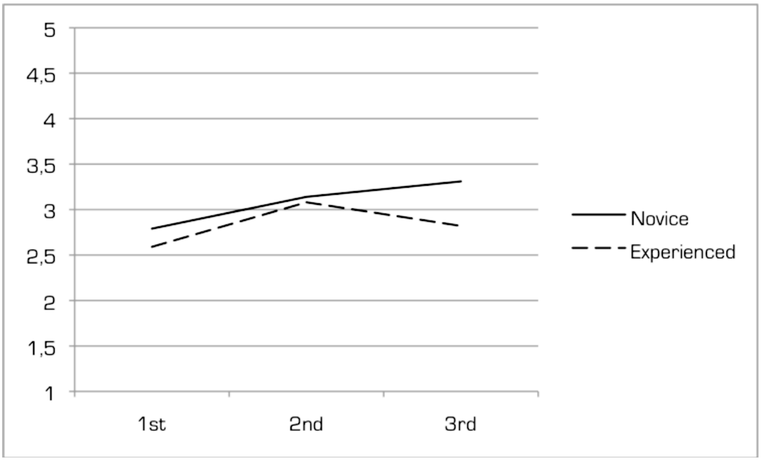
Hypothesis 4 formulates the expected effects of the *job experience* on the relationship between innovation and coded knowledge. We formulate this hypothesis as follows.

9.4.4 Hypothesis 4

Hypothesis 4

During the implementation of ZKR novice planners will show more increase of coded knowledge than experienced planners.

Figure 9.8a and *table 9.8a* below show the mean scores and standard deviations for coded knowledge split on job experience.

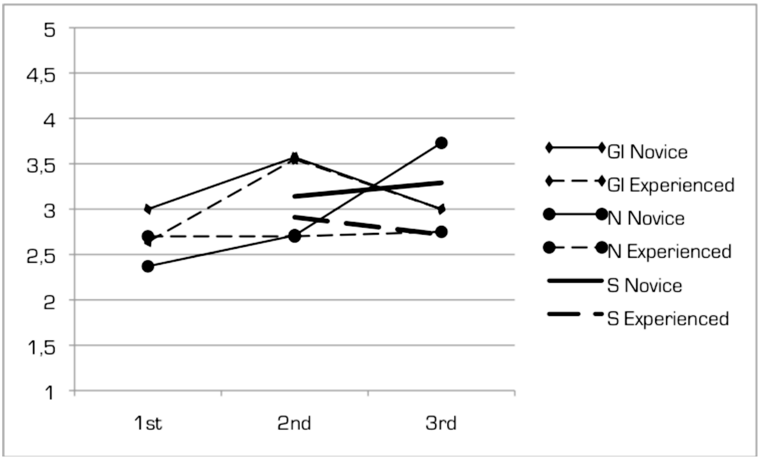


Job experience coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
Novice	2,79	0,81	3,14	0,92	3,31	1,06
Experienced	2,59	0,74	3,08	0,98	2,82	0,48

Figure 9.8a and table 9.8a: Mean values for coded knowledge split on job experience

The graph shows an increase in coded knowledge for both the novice planners and the experienced planners, after the *training* on ZKR as well as during the whole *implementation* of ZKR. From the graph there appears to be an effect for job experience for the *implementation* as well as for *experience*, but the t-test does not show this effect [*training*: $\eta^2 = 0.004$, $t = -0.252$, $df = 16$, $p = 0.804$; *implementation*: $\eta^2 = 0.037$, $t = -0.785$, $df = 16$, $p = 0.444$].

When we go one level deeper [see figure 9.8b and table 9.8b], we see the greatest difference between novice planners and experienced planners for the subtask of negotiating. In fact, the t-test shows an effect for job experience of planners on their coded knowledge; during the *implementation* process of ZKR novice planners show a stronger increase in their coded knowledge than do the experienced planners [$\eta^2 = 0.297$, $t = 2.600$, $df = 16$, $p = 0.019$]. The *experience* with ZKR showed a trend [$\eta^2 = 0.123$, $t = 1.501$, $df = 16$, $p = 0.153$].



Job experience coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
GI Novice	3,00	1,00	3,57	0,98	3,00	1,15
GI Experienced	2,64	1,03	3,55	0,82	3,00	0,89
N Novice	2,37	0,48	2,71	1,11	3,73	1,37
N Experienced	2,70	0,87	2,70	1,19	2,75	0,66
S Novice			3,14	1,21	3,29	0,95
S Experienced			2,91	1,14	2,72	0,78

Figure 9.8b and table 9.8b: Mean values for coded knowledge split on job experience

For gathering information the graph hardly shows an effect for job experience; only the *training* shows some difference, but the t-test confirms the none-effect [η^2 = 0.023, t = -0.615, df = 16, p = 0.547]. Scheduling does not show an effect for job experience either [η^2 = 0.020, t = 0.577, df = 16, p = 0.572]. *Table 9.8c* below gives an overview of all the t-test results.

Thus, for *hypothesis 4,* the effect of the job experience of the planners on the relation between their coded knowledge and the implementation of ZKR we conclude

Table 9.8c: T-test scores for coded knowledge split on job experience for all three subtasks and all differences in measurements

Job experience coded		η^2	t	df	p
All tasks	Training	0,004	-0,252	16	0,804
	Experience	0,048	0,893	16	0,385
	Implementation	0,037	0,785	16	0,444
Gathering information	Training	0,023	-0,615	16	0,547
	Experience	0,000	-0,043	16	0,966
	Implementation	0,043	-0,849	16	0,408
Negotiating	Training	0,021	0,582	16	0,569
	Experience	0,123	1,501	16	0,153
	Implementation	0,297	2,600	16	0,019**
Scheduling	Experience	0,020	0,577	16	0,572

- Job experience does not [significantly] affect the coded knowledge over all subtasks
- The job experience of planners does [significantly] affect the coded knowledge of the individual subtask negotiating in line with *hypothesis 4* – the implementation of ZKR affects the coded knowledge of novice planners more than the coded knowledge of experience planners; novice planners show a greater increase
- Gathering information shows a knowledge change direction opposite to that of negotiating and scheduling
- Overall, novice planners have more coded knowledge than do experienced planners.

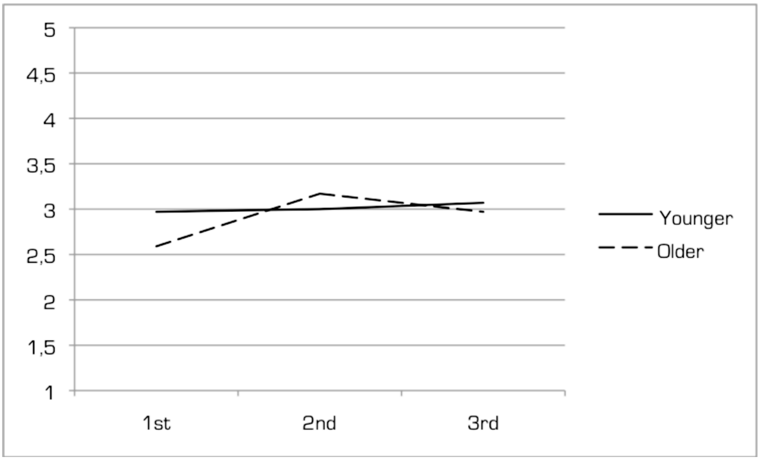
Hypothesis 5 formulates the expected effects of the moderator *age* on the relationship between innovation and coded knowledge. We formulate this hypothesis as follows.

9.4.5 Hypothesis 5

Hypothesis 5

During the implementation process of ZKR younger planners will show more increase of coded knowledge than older planners.

Figure 9.9a and *table 9.9a* below show the mean scores and standard deviations for coded knowledge split on age. The graph shows little difference in the coded knowledge of the younger planners compared to the older planners for the *implementation* of ZKR [$\eta^2 = 0.004$, $t = -0.245$, $df = 16$, $p = 0.809$]. The knowledge patterns do differ; the younger planners show a linear increasing pattern, while older planners show a stronger increase for the *training* [$\eta^2 = 0.032$, $t = -0.723$, $df = 16$, $p = 0.480$] and then they show a decrease for the *experience* with *ZKR* [$\eta^2 = 0.019$, $t = 0.556$, $df = 16$, $p = 0.586$].

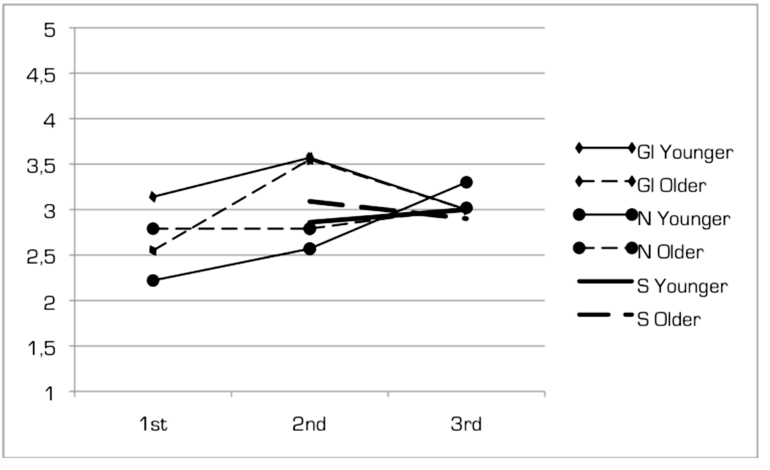


Age coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
Younger	2,97	0,81	3,00	0,84	3,07	1,06
Older	2,59	0,74	3,17	1,02	2,97	0,57

Figure 9.9a and table 9.9a: Mean values and SD's for coded knowledge over all three measurements split on age.

When we go one level deeper [see figure 9.9b and table 9.9b] we see that the patterns of the younger planners show similarities with the patterns of novice planners. And the patterns of the older planners show similarities with the patterns of the experienced planners. This is not surprising, as the job experience has a natural correlation with age.

Gathering information shows a trend for the *implementation* [$\eta^2 = 0.116$, $t = -1.452$, $df = 16$, $p = 0.166$], but not for the *training* [$\eta^2 = 0.066$, $t = -1.065$, $df = 16$, $p = 0.303$].



Age coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
GI Younger	3,14	1,07	3,57	0,98	3,00	1,15
GI Older	2,55	0,93	3,55	0,82	3,00	0,89
N Younger	2,22	0,40	2,57	1,13	3,30	1,38
N Older	2,79	0,84	2,79	1,17	3,02	0,90
S Younger			2,86	0,90	3,00	1,00
S Older			3,09	1,30	2,90	0,83

Figure 9.9b and table 9.9b: Mean values for coded knowledge split on age

Negotiating does not have any effects on age either. However, the trend for the implementation is in line with *hypothesis 5* [$\eta^2 = 0.123$, $t = 1.501$, $df = 16$, $p = 0.153$], in contrast to gathering information. Scheduling shows no effect for age [$\eta^2 = 0.020$, $t = 0.577$, $df = 16$, $p = 0.572$]. See *table 9.9c* for an overview of all the t-test results.

Table 9.9c: T-test scores for coded knowledge split on age for all three subtasks and all differences in measurements

		η^2	t	df	p
All tasks	Training	0,032	-0,723	16	0,480
	Experience	0,019	0,556	16	0,586
	Implementation	0,004	-0,245	16	0,809
Gathering information	Training	0,066	-1,065	16	0,303
	Experience	0,000	-0,043	16	0,966
	Implementation	0,116	-1,452	16	0,166
Negotiating	Training	0,021	0,582	16	0,569
	Experience	0,033	0,739	16	0,471
	Implementation	0,123	1,501	16	0,153
Scheduling	Experience	0,020	0,577	16	0,572

Thus, for *hypothesis 5*, the effect of the age of the planners on the relation between their coded knowledge and the implementation of ZKR we conclude

- No [significant] effects for the age of planners on the relationship between their coded knowledge and the implementation of ZKR
- Negotiating and scheduling show change patterns in line with *hypothesis 5* – the implementation of ZKR affects the coded knowledge of the younger planners more than the coded knowledge of the older planners; the younger

planners show a greater increase. Gathering information shows a trend in contrast to *hypothesis 5.*

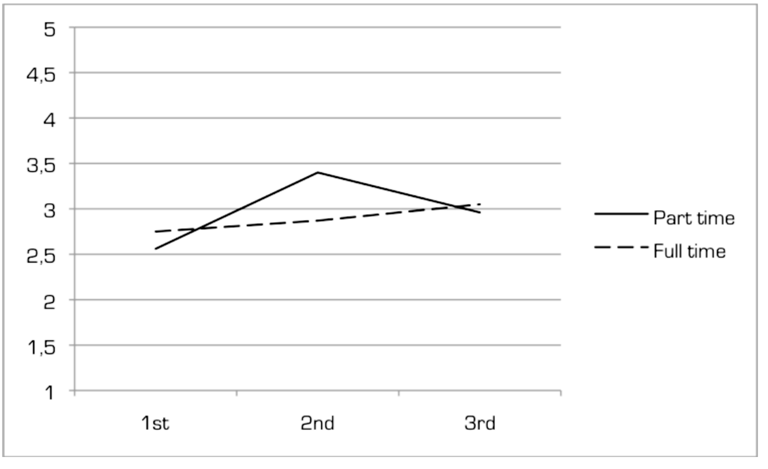
Hypothesis 6 formulates the expected effects of the hours per week that a planner works on the relationship between innovation and coded knowledge. We formulate this last hypothesis as follows.

9.4.6 Hypothesis 6

Hypothesis 6

During the implementation process of ZKR the part time planners will show less increase in their coded knowledge in comparison to full time planners.

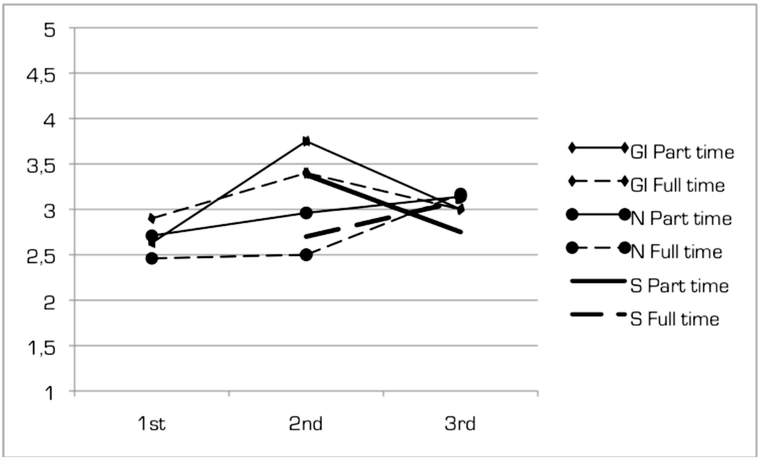
Figure 9.10a and *table 9.10a* below show the mean scores and standard deviations for coded knowledge split on contractual hours per week.



Working hours coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
Part time	2,56	0,86	3,40	1,06	2,96	0,65
Full time	2,75	0,68	2,87	0,79	3,05	0,88

Figure 9.10a and table 9.10a: Mean values and SD's for coded knowledge over all three measurements split on age.

The graph shows a small linear increasing pattern for full time planners [= 32 hours or more per week]; the part-time planners show a bigger increase for the *training* on ZKR, but they show a decrease for the *experience* with ZKR. Neither the *training* trend [$\eta^2 = 0.129$, $t = 1.540$, $df = 16$, $p = 0.143$, nor the knowledge change for the total *implementation* of ZKR [$\eta^2 = 0.004$, $t = 0.252$, $df = 16$, $p = 0.804$] are in line with *hypothesis 6*. The experience trend is in line with *hypothesis 6* [$\eta^2 = 0.106$, $t = 1.381$, $df = 16$, $p = 0.186$].



Working hours coded	1ST		2ND		3RD	
	M	SD	M	SD	M	SD
GI Part time	2,63	1,06	3,75	0,89	3,00	0,93
GI Full time	2,90	0,99	3,40	0,84	3,00	1,05
N Part time	2,71	0,84	2,96	1,07	3,14	0,99
N Full time	2,46	0,69	2,50	1,18	3,17	1,20
S Part time			3,38	1,41	2,75	0,89
S Full time			2,70	0,82	3,09	0,88

Figure 9.10b and table 9.10b: Mean values for coded split on working hours

At the level of the subtasks the graph shows an increase for all groups for the *training* on ZKR and a mixing trend of increasing a decreasing coded knowledge for the *experience* with ZKR; gathering information shows a decrease and negotiating shows an increase, while scheduling is mixed.

For the whole *implementation* of ZKR as well as for the *training* on ZKR gathering information shows a knowledge change pattern which contradicts *hypothesis 6* [implementation: $\eta^2 = 0.026$, $t = 0.649$, $df = 16$, $p = 0.526$; training: $\eta^2 = 0.082$, $t = 1.197$, $df = 16$, $p = 0.249$], while negotiating shows a change pattern in line with *hypothesis 6* for the whole *implementation* [$\eta^2 = 0.010$, $t = 0.411$, $df = 16$, $p = 0.686$] and for the *experience* on ZKR [$\eta^2 = 0.010$, $t = -0.411$, $df = 16$, $p = 0.686$].

Table 9.10c: T-test scores for coded knowledge split on contractual hours for all three subtasks and all differences in measurements

Contractual hours coded		η^2	t	df	p
All tasks	Training	0,129	1,540	16	0,143
	Experience	0,106	-1,381	16	0,186
	Implementation	0,004	0,252	16	0,804
Gathering information	Training	0,082	1,197	16	0,249
	Experience	0,022	-0,604	16	0,554
	Implementation	0,026	0,649	16	0,526
Negotiating	Training	0,008	0,349	16	0,731
	Experience	0,028	-0,673	16	0,511
	Implementation	0,010	-0,411	16	0,686
Scheduling	Experience	0,202	-2,014	16	0,061*

Interestingly, scheduling shows an effect for contractual hours on the *experience* with ZKR [$\eta^2 = 0.202$, $t = -2.014$, $df = 16$, $p = 0.061$]; the part time planners show less increase than the full time planners. In fact, the part time planners show a decrease in their coded knowledge compared to an increase of coded knowledge for the full time planners. In addition, all change patterns for the *experience* of ZKR are in line with *hypothesis 6*; over all tasks we see a trend, but only scheduling shows an effect of the contractual hours on the coded knowledge of the planners. See *table 9.10c* for an overview of the t-test results.

Thus, we conclude the testing of *hypothesis 6* with the following summation

- The number of contractual hours of the planners did not have an effect for the whole implementation of ZKR over all tasks
- The number of contractual hours showed a [significant] effect on the experience of scheduling in line with *hypothesis 6* – while part time planners showed a decrease in their coded knowledge as a result of their experience with ZKR, full time planners showed an increase
- The experience knowledge change patterns are all in line with hypothesis 6; scheduling shows a [significant] effect for the experience with ZKR

We will now conclude this section on the hypotheses testing with some preliminary conclusions.

9.4.7 Preliminary conclusions

- The testing of the hypotheses showed eight significant effects of which seven were in line with our expectations. Four of the significant effects applied to the whole implementation process. The one significant effect that was not in line with our expectations concerned the experience for coded knowledge on gathering information; however, this settled over the whole implementation process.
- The task of negotiating is considerably more in line with our expectations compared to the other two subtasks and the changes over all subtasks [14 changes in line with our expectations versus seven changes not in line]; overall, gathering information and scheduling respectively had the ratio's 11/10, 10/11 and 4/3. As for the size of the effects the tasks do not differ.
- The whole implementation process shows more effect than either training or experience. Also, the whole implementation process is more in line with our expectations than either the training on ZKR

or the experience with ZKR. The implementation shows 13 changes in line with our expectations versus eight expectations not in line compared to 11/10 for training and 15/13 for experience. The whole implementation process also shows more significant effects compared to training and experience [training: 2, both in line with our expectation; experience: 2, one in line and the other not in line with our expectation; implementation: 4, all in line with our expectation].

We preliminary conclude the following. In line with our expectations, coded knowledge [over all subtasks] increased during the implementation of ZKR. Thus, the implementation of ZKR makes the used codes stronger with more consensus. Interestingly, this effect is most prominent for the subtask of negotiating. So, although ZKR does not directly support the activity of negotiating, its use does lead to a structural change in the knowledge of negotiation. That is, the introduction of ZKR leads to the use of stronger concepts for negotiating.

A second remark regarding the increase of coded knowledge is that the impact of ZKR was most prominent after the training [compared to after the experience with ZKR or the implementation process as a whole]. That is, the training on ZKR showed a greater effect on the use of codes than did the actual use of ZKR overall. So the increase in code strength might not have established enough to endure actually working with ZKR; the new knowledge needs to be confirmed [trained] repeatedly in order to stabilize the stronger codes.

Theoretical knowledge and sensory knowledge do not seem to be affected significantly by the use of planning support software. The expected conversion of sensory knowledge into coded knowledge was not supported by the data.

In addition to the main effects we also focused on four person-related-characteristics, which we expected to influence the relation between innovation and knowledge: 1] education, 2] job experience, 3] age, and 4] contractual hours. Of these four personal characteristics *age* was the only characteristic that did not show a single significant effect. That is, we did not find any differences between younger and older planners. We did find education to affect gathering information during the total *implementation* of ZKR [coded knowledge] and to have an effect after the *training* [sensory knowledge], job experience affected [the coded knowledge of] negotiating during the *implementation* of ZKR and the number of contractual hours affected scheduling on the *experience* with ZKR. Thus, age does not seem to influence the learning process of planners in an implementation process; their education, job experience and contractual hours on the other hand do influence their knowledge types.

The hypothesis testing does not clearly conclude anything concerning the differences between the subtasks. We want to address this issue in the secondary analysis. In particular we want to explore in more detail possible differences between gathering information and negotiating [e.g. negotiating showed more results in line with our expectations than did gathering information]. In addition we also want the secondary analysis to address the differences between the stages of the implementation process, which seemed to result in contradictive effects.

Table 9.11: T-test scores for comparing the subtasks of GI, N, and S – for all three knowledge types for the effects of *training*, *experience* and *implementation*

		GI vs. N	GI vs. S	N vs. S
Sensory	Training	0,204		
	Experience	1,000	0,627	0,605
	Implementation	0,336		
Coded	Training	0,205		
	Experience	0,082*	0,072*	0,277
	Implementation	0,175		
Theoretical	Training	0,854		
	Experience	0,920	0,336	0,404
	Implementation	1,00		

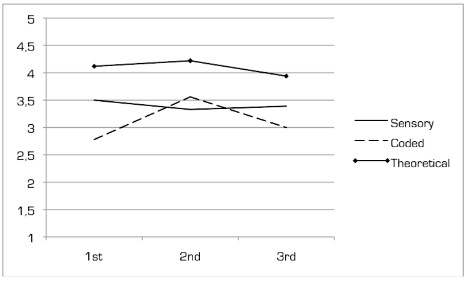
9.5 Secondary analysis

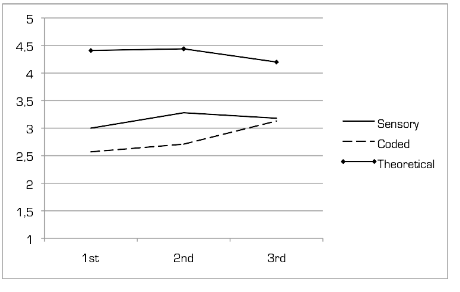
9.5.1 Comparing the subtasks

A t-test comparing the subtasks per knowledge type again showed significant effects for coded knowledge; gathering information significantly differed from negotiating as well as from scheduling for the effect of having *experience* with ZKR [see table 9.11]. In other words, actually starting to work with ZKR had a different effect when comparing gathering information and negotiating, but also comparing gathering information and scheduling. Whereas the coded knowledge of negotiating steadily increased, the coded knowledge for gathering information strongly decreased after a strong increase for the training [see also tables and figures 9.12]. All in all coded knowledge did increase for gathering information, although not significantly. So we can conclude differences in the effect of ZKR on the different subtasks. Negotiating is effected more strongly.

9.5.2 Training versus experience

A t-test compared the differences in effect for the three knowledge types with a focus on: 1] the effect of the *training* with the effect of the *experience* with ZKR, 2] the effect of the *training* with the effect of the whole *implementation*, and 3] the effect of the *experience* with ZKR with the effect of the whole *implementation*.





	Gathering Information			Negotiating		
	1st	2nd	3rd	1st	2nd	3rd
Sensory	3,50	3,33	3,39	3,00	3,28	3,18
Coded	2,78	3,56	3,00	2,57	2,71	3,13
Theoretical	4,12	4,22	3,94	4,41	4,44	4,20

Figures 9.12 a [left: GI], 9.12b [right: N] and table 9.12: The mean scores for the three knowledge types for the subtasks of gathering information and negotiating

Again coded knowledge showed significant effects, but only for gathering information [see also table 9.13]. Firstly, the effect of the training was stronger than the effect of actually working with ZKR. Then, the effect of the training was bigger than that for the whole implementation and thirdly, actually working with ZKR had a different effect compared to the whole implementation process. The most interesting of these three effects is the difference between the effect of the training and the effect of the whole implementation. *Hypothesis 1b* [significant] effect for the implementation of ZKR for the coded knowledge of gathering information. However, comparing the increase of coded knowledge of the training to the increase of coded knowledge of the whole implementation does reveal a significant difference. Thus, although the whole implementation does not seem to show a significant effect on the coded knowledge of the planners for gathering information there is a difference in effect; this shows the importance of research over longer periods of time, as the whole implementation process of ZKR does seem to have a stronger effect on planners than just the training.

Table 9.13: T-test scores for comparing the effects of *training*, *experience* and *implementation* – for all three knowledge types for the subtasks of GI and N

		Training vs. Experience	Training vs. Implementation	Experience vs. Implementation
Sensory	Gathering information	0,679	0,859	0,528
	Negotiating	0,807	0,836	0,512
Coded	Gathering information	0,022**	0,066*	0,014**
	Negotiating	0,615	0,339	0,795
Theoretical	Gathering information	0,541	0,535	0,653
	Negotiating	0,765	0,686	1,00

9.6 Findings

9.6.1 Increase of coded knowledge

The introduction of a new way of working, in our study the implementation of the planning support software of ZKR, structurally affected the knowledge types of the planners who worked with ZKR. More specifically, the coded knowledge significantly increased. That is, the planners of Bartiméus can more easily verbalize their actions after they have started to work with the planning support software ZKR. We understand this structural change in knowledge types in that the need for communication will emerge. This will elicit reflection on ones actions and sets the coding process in motion, which takes the knowledge of the planners to a 'higher' level of knowledge, a more coded knowledge.

Theoretical knowledge and sensory knowledge do not seem to be affected significantly by the use of planning support software. Both theoretical knowledge and sensory knowledge neither have an [significant] effect, nor a trend. We do, however, notice that the theoretical knowledge of the planners shows a consistent change pattern in that it decreases after the planners have had the *training* on ZKR as well as over the whole *implementation* process of ZKR. Sensory knowledge does not show a consistent change pattern during the implementation process of the planning support software. The expected conversion of sensory knowledge into coded knowledge was not supported by the data. Thus, working with ZKR only increases the coded knowledge of the planners; sensory knowledge and theoretical knowledge are not affected. Thus, we observed a knowledge change in the sense that planners seem to be more aware of their actions and they can put these actions into words.

9.6.2 Differences between tasks

As for the difference in performed task we first note an interesting difference in dominance of the knowledge types. Gathering information scores higher on sensory knowledge and on coded knowledge, but negotiating scores higher on theoretical knowledge.

As for the differences in knowledge dynamics between the subtasks the most striking difference is the effect of the *training* for coded knowledge; whereas the verbalization for gathering information increased sharply the verbalization on negotiating was not in the least affected by the training on ZKR [.01 vs. .63]. We do note that over the whole implementation process the verbalization skills on negotiating did increase [significantly], but the verbalization skills on gathering information did not [we might say that they moved towards a trend]. Gathering information seems to be more sensitive to training than is negotiating. But negotiating on the other hand does seem to show some sort of incubation period and overall is affected by the implementation of ZKR.

9.6.3 Personal characteristics

In addition to the main effects we also focused on four person-related-characteristics, which we expected to influence the relation between innovation and knowledge: Of personal education, job experience, age, and contractual hours *age* was the only characteristic that did not have a single significant effect. Job experience and the education level of the planners influenced their verbal expression. That is, senior educated planners profited more from the implementation of ZKR in that their verbal expression on gathering information showed a greater increase in comparison to the higher educated planners. We do note that the 'level' of the coded knowledge of senior educated planners was lower than that of the higher educated planners to begin with. After the implementation on ZKR the coded knowledge of these two groups of planners had reached the same level. As for the influence of job experience, novice planners profited more from the implementation process than experienced planners did.

The verbal skills on negotiating of the novice planners increased significantly more than the verbal skills of the experienced planners. In fact, the novice planners started out inferior to the experienced planners but surpassed them after having worked with ZKR; the experienced planners did not seem to be affected at all by the changes in their work. We do want to note at this point that it could well be that the more experienced planners might have used the planning support software of ZKR in a different way than the novice planners did. From the in-depth interviews we know that some planners did not change their way of working; they continued to make the duty roster by hand and then used ZKR only to register this duty roster. Unfortunately, we do not have this detailed information on all planners, so we cannot conclude that this distinguished the novice planners from the experienced planners.

9.6.4 Implementation stages

Then, in studying what actually happens to the knowledge of the planners during the implementation process we came across an interesting difference in effect between the training on ZKR and the experience with ZKR. That is, we implicitly assumed that actually working with ZKR would extend an effect on the knowledge types of the planners initiated by the training that the planners had on ZKR. But this was not what we found. In fact, in some cases [check, formulated differently] the effect established by the training was completely undone by the experience on ZKR. Or maybe we should say that one single training was not enough; the planners could not incorporate the newly obtained knowledge just by using the new planning support software.

9.6.5 In conclusion

In answering the research questions posed in *chapter 6* we can say that an organizational innovation such as the implementation of planning support software causes structural changes in the knowledge types of planners. Particularly, the coded knowledge of the planners is affected. Interestingly, the coded knowledge of negotiating is affected the most, while this subtask of planning is not even directly supported by the ZKR panning support software. This is a strong indication that organizational innovation does not only affect the activities that are directly sup-ported by ZKR; it indicates that the impact of ZKR reaches further, to indirectly related activities. Organizational innovation actually structurally changes the way of working and, more dramatically, the knowledge of people. The personal characteristics of planners were shown to be a factor of consideration and also the stages within the implementation process show differences in knowledge dynamics.

In the final chapter of this thesis we will reflect on these results.